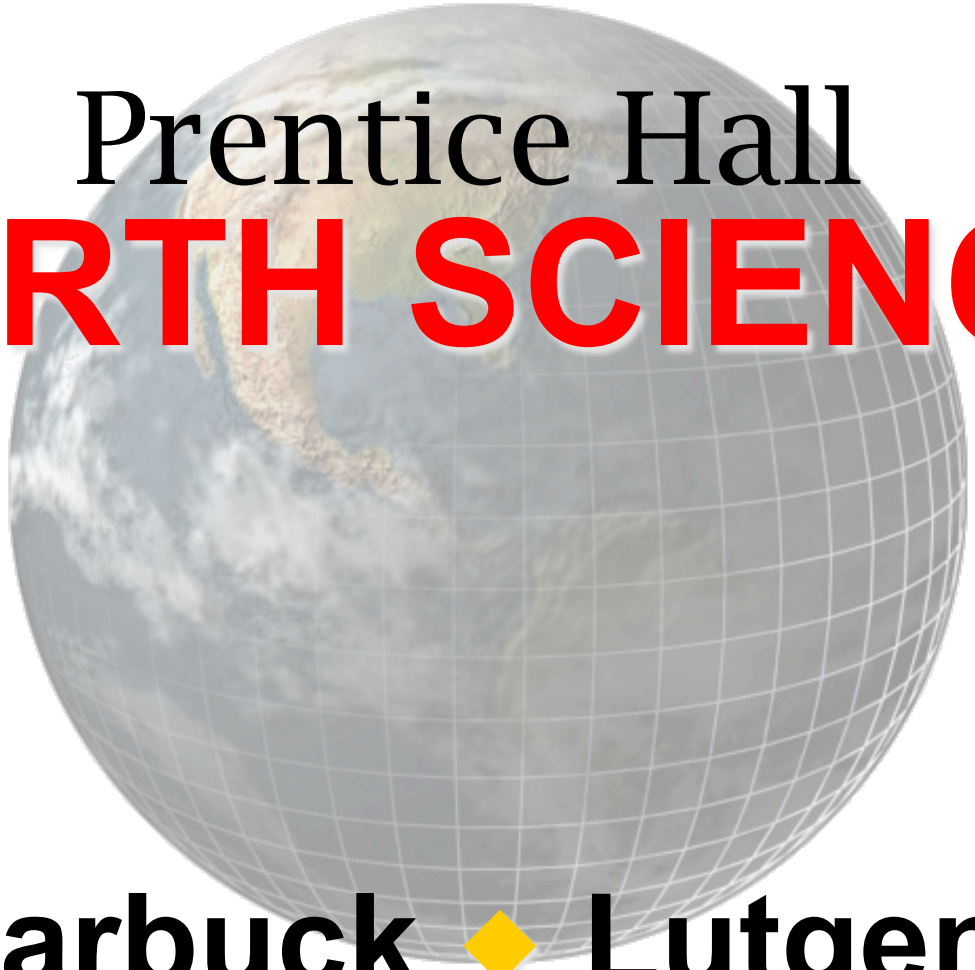
Prentice Hall

EARTH SCIENCE



Tarbuck ◆ Lutgens

4 The Rock Cycle

Rocks

- **Rocks** are any solid mass of mineral or mineral-like matter occurring naturally as part of our planet.
- Types of Rocks

  1. **Igneous rock** is formed by the crystallization of molten magma.

4 Igneous Rocks

Formation of Igneous Rocks

1. **Intrusive igneous rocks** are formed when magma hardens beneath Earth's surface.

2. **Extrusive igneous rocks** are formed when lava hardens.

Course-Grained Igneous Texture

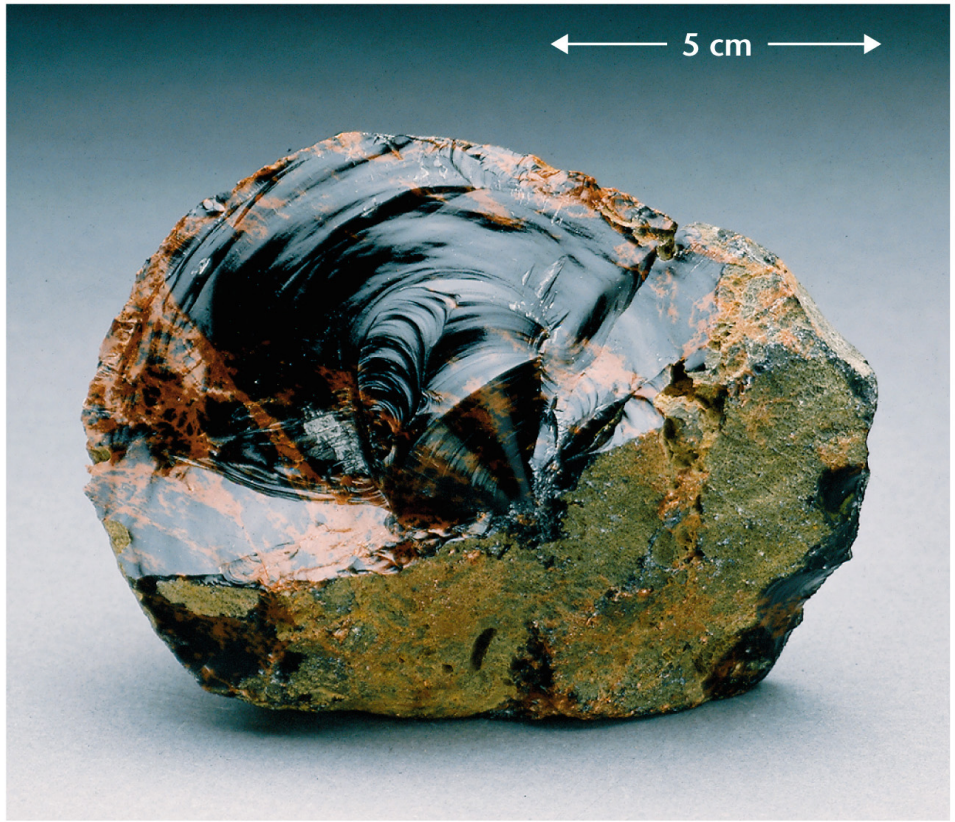
Fine-Grained Igneous Texture

4 Igneous Rocks

Classification of Igneous Rocks

1. Texture (continued)
   - Glassy texture is caused by very rapid cooling.
   - **Porphyritic texture** is caused by different rates of cooling resulting in varied sized minerals.
2. Composition
   - **Granitic composition** rocks are made mostly of light-colored quartz and feldspar.

Obsidian Exhibits a Glassy Texture.



Porphyritic Igneous Texture

4 Igneous Rocks

Classification of Igneous Rocks

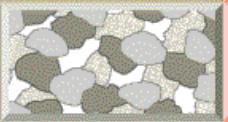
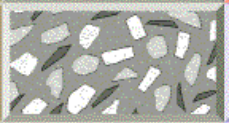
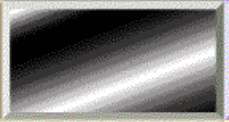
2. Composition (continued)

- **Basaltic composition** rocks are made mostly of dark-colored silicate minerals and plagioclase feldspar.
- **Andesitic composition** rocks are between granitic light-color minerals and basaltic composition dark-colored minerals.
- **Ultramafic** composition rocks are made mostly from iron and magnesium-rich minerals.

Basalt

Classification of Igneous Rocks

Table 1 Classification of Major Igneous Rocks

Chemical Composition			Granitic	Andesitic	Basaltic	Ultramafic
Dominant Minerals			Quartz Potassium feldspar Sodium-rich plagioclase feldspar	Amphibole Sodium- and calcium-rich plagioclase feldspar	Pyroxene Calcium-rich plagioclase feldspar	Olivine Pyroxene
TEXTURE	Coarse-grained		**Granite**	**Diorite**	**Gabbro**	**Peridotite**
	Fine-grained		**Rhyolite**	**Andesite**	**Basalt**	**Komatiite** (rare)
	Porphyritic		"Porphyritic" precedes any of the above names whenever there are appreciable phenocrysts.			Uncommon
	Glassy		**Obsidian** (compact glass) **Pumice** (frothy glass)			
Rock Color (based on % of dark minerals)			0% to 25%	25% to 45%	45% to 85%	85% to 100%

4 Sedimentary Rocks

Formation of Sedimentary Rocks

- Weathering, Erosion, and Deposition
  - **Erosion** involves the weathering and the removal of rock.
  - **Deposition** occurs when an agent of erosion—water, wind, ice, or gravity—loses energy and drops sediments.

4 Sedimentary Rocks

Formation of Sedimentary Rocks

- Compaction and Cementation
  - **Compaction** is a process that squeezes, or compacts, sediments.
  - **Cementation** takes place when dissolved minerals are deposited in the tiny spaces among the sediments.

4 Sedimentary Rocks

Classification of Sedimentary Rocks

- Two Main Groups
  1. **Clastic sedimentary rocks** are composed of weathered bits of rocks and minerals.
     - Classified by particle size
     - Common rocks include
       - Shale (most abundant)
       - Sandstone
       - Conglomerate

Shale with Plant Fossils

Conglomerate

4 Sedimentary Rocks

Classification of Sedimentary Rocks

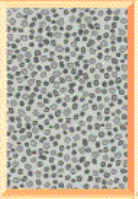
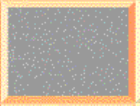
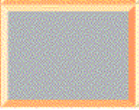
- Two Main Groups

  2. **Chemical sedimentary rocks** form when dissolved substances precipitate, or separate, from water.

     - Common rocks include
       - limestone—most abundant chemical rock
       - microcrystalline quartz known as chert, flint, jasper, or agate
       - evaporites such as rock salt or gypsum
       - coal

Fossiliferous Limestone

Classification of Sedimentary Rocks

Clastic Sedimentary Rocks			
Texture (grain size)		**Sediment Name**	**Rock Name**
Coarse (over 2 mm)		Gravel (rounded fragments)	**Conglomerate**
		Gravel (angular fragments)	**Breccia**
Medium (1/16 to 2 mm)		Sand	**Sandstone**
Fine (1/16 to 1/256 mm)		Mud	**Siltstone**
Very fine (less than 1/256 mm)		Mud	**Shale**

Chemical Sedimentary Rocks			
Composition	**Texture** (grain size)	**Rock Name**	
Calcite, $CaCO_3$	Fine to coarse crystalline	**Crystalline Limestone**	
		Travertine	
	Visible shells and shell fragments loosely cemented	**Coquina**	**Biochemical Limestone**
	Various size shells and shell fragments cemented with calcite cement	**Fossiliferous Limestone**	
	Microscopic shells and clay	**Chalk**	
Quartz, SiO_2	Very fine crystalline	**Chert (light colored) Flint (dark colored)**	
Gypsum $CaSO_4 \bullet 2H_2O$	Fine to coarse crystalline	**Rock Gypsum**	
Halite, NaCl	Fine to coarse crystalline	**Rock Salt**	
Altered plant fragments	Fine-grained organic matter	**Bituminous Coal**	

4 Sedimentary Rocks

Features of Some Sedimentary Rocks

- Features of sedimentary rocks are clues to how and where the rocks are formed

4 Metamorphic Rocks

Formation of Metamorphic Rocks

- ***Metamorphism*** means "to change form."
- Most metamorphic changes occur at elevated temperatures and pressures.
- Conditions for formation are found a few kilometers below the Earth's surface and extend into the upper mantle.

4 Metamorphic Rocks

Formation of Metamorphic Rocks

- **Contact metamorphism** occurs when magma moves into rock.
  - Occurs near a body of magma
  - Changes are driven by a rise in temperature.

4 Metamorphic Rocks

Formation of Metamorphic Rocks

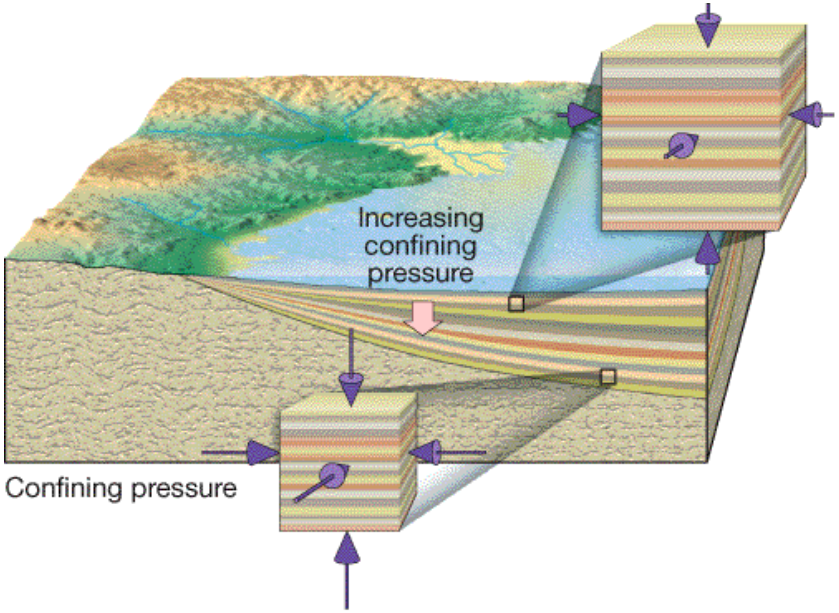
- **Regional metamorphism** results in large-scale deformation and high-grade metamorphism.
  - Directed pressures and high temperatures occur during mountain building.
  - Produces the greatest volume of metamorphic rock

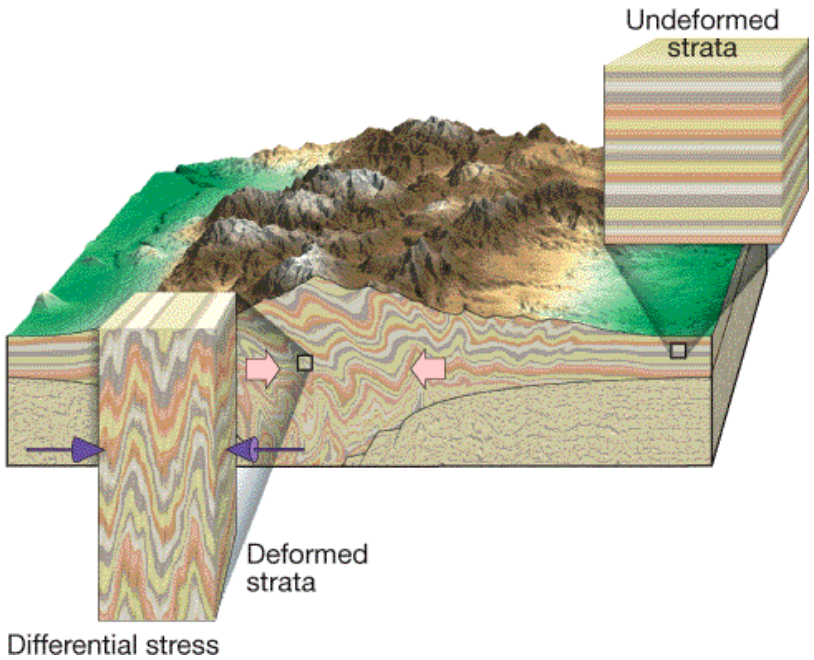
4 Metamorphic Rocks

Agents of Metamorphism

- Heat
  - Provides the energy needed to drive chemical reactions
- Pressure
  - Causes a more compact rock with greater density

Origin of Pressure in Metamorphism





4 Metamorphic Rocks

Agents of Metamorphism

- **Hydrothermal Solutions**
  - Hot water-based solutions escaping from the mass of magma
  - Promote recrystallization by dissolving original minerals and then depositing new ones

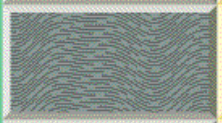
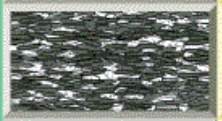
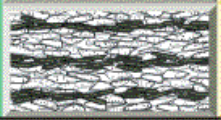
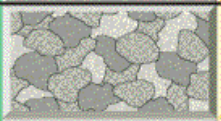
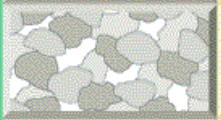
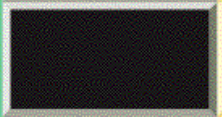
4 Metamorphic Rocks

Classification of Metamorphic Rocks

- Two main categories
  1. **Foliated Metamorphic Rock**
     - Has a banded or layered appearance
  2. **Nonfoliated Metamorphic Rock**
     - Does not have a banded texture

Classification of Metamorphic Rocks

Table 3 Classification of Major Metamorphic Rocks

Rock Name		Texture		Grain Size	Comments	Parent Rock
Slate	Increasing Metamorphism	Foliated		Very fine	Smooth dull surfaces	Shale, mudstone, or siltstone
Phyllite				Fine	Breaks along wavy surfaces, glossy sheen	Slate
Schist				Medium to Coarse	Micaceous minerals dominate	Phyllite
Gneiss				Medium to Coarse	Banding of minerals	Schist, granite, or volcanic rocks
Marble		Nonfoliated		Medium to coarse	Interlocking calcite or dolomite grains	Limestone, dolostone
Quartzite				Medium to coarse	Fused quartz grains, massive, very hard	Quartz sandstone
Anthracite				Fine	Shiny black organic rock that fractures	Bituminous coal

Gneiss Typically Displays a Banded Appearance

Marble—A Nonfoliated Metamorphic Rock